EFFECTS OF 2,4-D AMINE ON ROOT MORPHOLOGY AND MINERALS OF ZEA SEEDLINGS

By

Maimona Abd-El Aziz Kord

Faculty of Science, Botany Department, Cairo University.

ABSTRACT

In growth chamber studies, 10 p.p.m 2,4-D amine increased the number of seminal roots, reduced lateral root production, decreased root extension, caused root tips to swell and reduced root dry weight of Zea maize seedlings. However 5 p.p.m. 2,4-D amine caused only slight damage. At the end of the 2-wk growth period, damaged seedlings showed signs of recovery, which included an increased number of seminal roots, development of normal root extensions from clubbed root tips, and development of normal lateral root patterns. 2,4-D amine increased percentage N, P and K in zea plants.

INTRODUCTION

There is a considerable literature on the effect of 2,4-D on higher plants as regards the physiology, morphology and biology of this group of plants when subjected to various treatment of 2,4-D. (Lee, 1972; Rensburg and Villiers, 1978 a & b; Arkhangel'skii et al. 1982 and several others). All these reports revealed that the lower concentrations of 2,4-D may be have as growth regulators, but at higher concentrations it has antiphotosynthetic effects on all tested plants.

Mc Cracken et al., 1981 showed that 2,4-D decreased chlorophyll content in many plants.

However, Zvyagintsev et al. (1975) demonstrated the increase in chlorophyll content of Calamagrostis arundinacea cells under the influence of wide range of 2,4-D concentrations.

As a result of 2,4-D applications to higher plants, the electrophoretic picture of the protein fractions was subjected to qualitative and quantitative changes and the picture have been considerably altered (Baker et al., 1980; and Zych, Monika, 1980). In this connection, Ladonin et al. (1980) indicated that the increase in cell protein of pea plants treated with 2,4-D was due to the herbicide-induced decrease in protein decomposition rather than to increased protein synthesis.

As regards respiration in 2,4-D treated plants, it was subjected, in most cases, to pronounced disturbances (Makovcovà et al., 1976). Chodovà (1980) indicated that respiration rate is a sensitive criterion of the action of 2,4-D, since the consumption of O_2 in 2,4-D-treated plants of Sinapis alba was significantly decreased by continuous exposure to the herbicide; a phenomenon that was accompanied by a concomitant decrease in protein and sugar contents of cells.

Halvankar and Patil, (1983) came to the conclusion that the germination percentage of presoaked seeds of durum and bread wheats decreased if treated with high concentrations of 2,4-D. According to Holmes and Kapusta (1980) the addition of 2,4-D amine at several rates to soybean plant resulted in a significant decrease in the yield.

Little information is available about the effects of herbicides on the minerals of plants. Most studies have examined whether a nutrient will alter the phytotoxicity by some interaction in the soil or plant. Sameni et al. (1976) exposed sunflower plants (Helianthus annuus L.) to some herbicides and observed a non-significant increase of percent nitrogen in leaf and stem tissue.

MATERIAL and METHODS

For this investigation Zea maize plant was chosen. Seeds were washed with water sterilised with 1 % H_2O_2 and washed again. The seeds were then air dried and sown in the soil which was air dried and passed through a 2 mm sieve. This soil had a pH 7.5 contained 3.09 % organic matter.

The soil was manured with fertilizer (1 g ammonium sulfate per 1 Kilo of soil as recommended by the Ministry of Agriculture), and 2,4-D amine herbicide at 0, 5 and 10 ppm was added and mixed thoroughly. Herbicide concentrations were determined in preliminary experiments such that the highest conc. 10 ppm would cause considerable damage to zea seedlings without being lethal.

Containers used for growing plants were constructed from black plastic plumbing tubes, which had a 5.1 cm inside diam. and were 55 cm long. The tubes were cut lengthwise on one side to facilitate later soil removal. The longitudinal cut was sealed and one end of the tube was fitted with a rubber stopper. Two strong rubber bands were placed around each tube to prevent opening of the cut during the experiment. Tubes were filled with either control soil or herbicide-treated soil. Each tube was seeded at the 2.5-cm soil depth, and wre placed randomly in a growth chamber at 22^{o}C. The relative humidity was approximately 45 %.

Plants samples were taken at 3, 6, 9, 12 and 15 days old. At each sampling date the cuts along the tubes were opened slightly, the soil was then washed away to recover the entire root system. Measurements were then made on the seminal and lateral roots. The seminal root diameter was measured using a microscope with a calibrated micrometer eyepiece. The root systems wre then oven dried to measure dry-weight production.

Other samples were taken at 21 and 35 days-old. Their roots were washed free of soil and separated from the shoot material.

Both roots and shoots were oven dried, finely ground and subjected to the H_2SO_4-H_2O_2 digestion procedure described by Thomas et al. (1967). Nitrogen and phosphorus wre analyzed with an auto analyzer, calcium, magnesium and potassium with an atomic absorption spectrophotometer.

RESULTS and DISCUSSION

The primary root systems of the 15-days old control plants were well developed and the secondary were just beginning to develop. Total dry weight of the 15 days old plants was significantly reduced by 10 ppm herbicide, whereas 5 ppm had little effect as shwon in Fig. 1. This indicated a threshold phytotoxic response that occurred between 5 and 10 ppm 2,4-D amine under the conditions used in this expriment. Three days after seeding the first three seminal roots had developed regardless of herbicide conc. . The number of seminal roots was relatively constant by day 9 for control, with an average of 4.8/plant by the fifteenth day. Seminal root numbers of the 10 ppm herbicide-treated plants remained constant after 6 days with an average of 5.8/plant. The 5 ppm herbicide-treated plants were intermediate with an average of 5.1 to 5.7 for the 12- and 15-days old plants, respectively. Thus, a stimulatory response from 2,4-D amine caused the zea seedlings to produce more seminal roots. No reports of a similar effect could be found in the literature. The maximum number of seminal roots a wheat plant can produce is six (McCall, 1934 and Peterson, 1965).

2,4-D amine at 10 ppm reduced the total seminal root length per plant of the 15-days old plants to approximately one-third the length of the controls (Fig. 1). The increase in the number of seminal roots did not compensate for the reduction in total seminal root length at this growth stage. The 5 ppm treatment did not significantly affect total seminal root length per plant compared to the controls.

Root diameters ranged from 0.442 to 0.553 mm for the control plants (Table 1). Percival (1921) has reported diameters for seminal wheat roots of 0.50 to 0.75 mm. Seminal root diameter appeared to be a function of plant age since the diameter generally decreased with time independent of the herbicide concentration.

2,4-D amine concentration of 10 ppm increased the average root diameter. The increase in radial expansion was greatest near the root tip giving the roots a club-like appearance. The root diameters were not significantly increased by 5 ppm conc. Lateral roots were not present by day 3 but were beginning to develope 6 days after seeding. 2,4-D amine at 5 ppm tended to reduce the average lateral root length with day-9 and day-15 plants significantly different than the controls (Fig. 1). The 10 ppm conc., instead of further reducing the average lateral length, was either equal to the 5 ppm value (day 12) or significantly higher than the controls. This response by the lateral roots to the higher herbicide concentration can be atributed to the production of abnormally long lateral

Plant age (days)	Herbicide Conc. (ppm)	Average seminal root diameter (mm)
3	0	0.553
	5	0.578
	10	0.617
6	0	0.509
	5	0.517
	10	0.589
9	0	0.471
	5	0.504
	10	0.582
12	0	0.442
	5	0.459
	10	0.520
15	0	0.453
	5	0.455
	10	0.528
LSD		0.040

Table 1: Effect of 2,4-D amine on the diameters of seminal roots of zea seedlings.

roots. This is of importance since the number of lateral roots produced per cm of seminal root is significantly lower for the 10 ppm treatment compared to the 5 ppm treatment (Fig. 1), whereas the total production of lateral roots from the 10 ppm and 5 ppm treatments does not differ significantly.

The zea plants appeared to have a compensating mechanism for the reduction in growth of the parent seminal roots at the higher conc. of 2,4-D amine. However, this compensation was unable to completely offset the reduced total lateral root production (Fig.1). The lateral root data also shows that the reduction of total lateral root length per cm of seminal root by 5 ppm herbicide was due to a reduction in the average length per individual lateral root and the reduction of 10 ppm herbicide was mainly due to a reduction in number of lateral roots produced.

Barrentine and Warren (1971) found that the production of adventitious roots in sarghum bicolor increased in the shoot zone overlaying herbicide-treated soil layer in the upper root zone. These reports suggest that plants compensate for root inhibition in herbicide-treated soil by growing roots outside the herbicide_treated soil in the initial dose is not lethal. Our data show that damaged zea roots can recover within soil treated with a nonlethal dose of 2,4-D amine.

Root and shoot dry weight of the zea plants was significantly reduced by 10 ppm herbicide, whereas 5 ppm herbicide had little effect (Table 2). This reduction at 10 ppm was less for the 35-days old plants than for the 21-days old plants.

Plant part	Root					
Plant age (days)	21			35		
herbicide conc. (ppm)	O	5	10	0	5	10
Dry wt (mg)	81.9	82.4	30.9	229.7	204.5	144.1
LSD	20.8					

Plant part	Shoot					
Plant age (days)	21			35		
herbicide conc. (ppm)	0	5	10	0	5	10
Dry wt (mg)	166.8	161.9	63.4	416.6	392.2	351.4
LSD	36.9					

Table 2 : Effect of 2,4-D amine on dry weight of zea plants.

Results from the plant tissue mineral analyses showed percent Ca and Mg increased and percent K, N, and P decreased as the herbicide concentration increased (Fig. 2). These effects were less pronounced in the older plants, indicating the plants were overcoming the herbicide effects in later growth. The increase in percent Ca and Mg were not due to the reduction of plant biomass caused by 2,4-D amine, since dry weight production was unaffected by 5 ppm conc., but the percent Ca was greatly increased (Fig. 2). Furthermore, if it had been a concentrating effect, the percent N, P, and K should have increased. Mg was less affected than Ca and by day 35 the percent Mg had returned to normal but the percent Ca was still higher than in the controls.

Generally, percent K increased in the roots and decreased in the shoots of the 21-days old plants grown in herbicide-treated soil. Possible K movement into the shoot material may have been restricted causing an accumulation of K in the roots relative to the control values. There is evidence that some herbicides reduced the transport of two photosynthetic herbicides, atrazine and simazine, from the roots to the shoots of pea and soybean (O'Donovan and Prendeville, 1976).

Percent P content for the 21-days old plants grown in the 10 ppm herbicide-treated soil, was reduced 56 and 44 % in root and shoot tissue, respectively. The reduction was less with the older plants. P content expressed as shoot-to-root ratio was not altered by 5 ppm of 2,4-D amine, indicating that the reduction of percent P was similar throughout the plant. However, 10 ppm reduced the ratio and thus showed a greater reduction in the shoots than in the roots.

N was less affected by 2,4-D amine than the other nutrients examined. Nevertheless, herbicide-treated plants had significantly reduced percent N at both concentrations (Fig. 2). Sameni et al (1976) have observed a non-significant increase in percent N in leaf and stem tissue of sunflowers exposed to some herbicides.

These results show that zea seedlings are capable of recovering from sublethal concentrations of 2,4-D amine and that both root morphological and plant minerals concentrations undergo changes.

REFERENCES

Arkhangel'shii, N.S.; Kostrikin, V.M.; Gruzdev, L.G. and Luzik, L.V. (1980): Yielding capacity of different fodder beet cultivars and protein and amino acid content in the roots after using 2,4-D as a growth regulator. Izvestiya: Timiryazevskoi Sel'skokhozyaistvennoi. Akademii. 2: 40-47.

Baker, R.L.; Powell, J.; Morrison, R.D. and Stritzke, J.F. (1980). Effects of atrazine, 2,4-D and fertilizer on crude protein content of Oklahoma, USA tall-grass prairie. J. Range Manage. 33: 404-407.

Barrentine, W.L. and Warren, G.F. (1971). Differential phytotoxicity of some herbicides. Weed Sci. 19 : 31-37.

Chodová, D. (1980). The effect of the herbicide 2,4-D on some physiological processes in the plants of white mustard and scenthess mayweed shortly after application.Ochr. Rostl. 16: 137-145.

Halvankar, G.B.; Patil, V.P. (1983). Effects of agrochemicals on germination in tetraploid and hexaploid wheats. Biovigyanam-a, 1, 27-32.

Holmes, R.L.; Kapusta, G. (1980). Soybean tolerance to and weed control with 2,4-D amine. Proceedings North Central Weed Control Conference, 1979. Weed Research 1980. 34: 34-35.

Ladonin, V.F.; Chesalin, G.A.; Samoilov, L.N.; Spesivtsev, L.G. and Taova, V.I. (1980). The application of N^{15} to investigating the influence of herbicides on crop and weed plants. Report 2. The action characteristics of herbicides on the nitrogenous metabolism of resistant and susceptible plants. Agrochimiya. 17: 116-122.

Lee, T.T. (1972). Changes in indoleacetic acid oxidase isoenzymes in tobacco tissues after treatment with 2,4-D. Plant Physiol. 49: 957-960.

Makovcová, L.; Sindelar, L. and Polak, Z. (1976). Changes in respiration and BSMV concentration of infected wheat plants after treatment with 2,4-D. Biologia Plantarum. 18: 190-194.

McCall, M.A. (1934). Developmental anatomy and homologies in wheat. J. Agric. Res. 48: 283-321.

Mc Cracken, D.A.; Ort, D.R. and Nadakavukaren, M. (1981). The effects of 2,4-D altered chloroplast development on photosynthesis. Physiologia Plantarum. 52: 285-291.

O'Donovan, J.T. and Prendeville, G.N. (1976). Interactions between soil-applied herbicides in the roots of some legume species. Weed Res. 16: 331-336.

Percival, J. (1921). The wheat Plant. London, Duckworth and Co. 463 pp.

Peterson, R.F.(1965). Wheat. Interscience Publishers Inc., New York, 422 pp.

Rensburg, A.J.J. Van and Villiers, O.T. DE. (1978a). Biochemical changes in Raphanus raphanistrum treated with 2,4-D. Agroplantae. 10: 1-3.

Rensburg, A.J.J. Van and Villiers, O.T. DE. (1978b). Effect of 2,4-D and MCPA on α-amylase and cellulose activity in roots of Raphanus raphanistrum. Agroplantae. 10: 5-7.

Sameni, A.M.; Maftoun, M.; Hojjati, S.M. and Shcibany, B. (1976). Effect of fertilizer-N and herbicides on the growth and N content of sunflower. Agron. J. 68: 285-288.

Thomas, R.L.; Shcard, R.W. and Moyer, J.R. (1967). Comparison of conventional and automated procedures for nitrogen, phosphorus, and potassium analysis of plant material using a single digestion. Agron. J. 59: 240-243.

Zvyagintsev, D.G.; Aseeva, I.V.; Samokhvglov, A.N.; Grishina, N.S.; Gorcharak, L.G.; Altakhov, M.D. and Gorcharuk, L.M. (1975). Improving hill pastures with the aid of 2,4-D butyl ester. Problemy Sel'skokhozyaistvennoi Nauki v Moskovskom Univ. edited by G.V. Dobrovol'skii: 306-323.

Zych, Monika (1980). Changes in the quality of grain , flour and bread of several wheat varieties occuring under the effect of herbicides, 2. The influence of herbicides on the milling and baking properties of winter wheat varieties. Hodowla Rosl Aklim Nasienn. 24: 23-36.

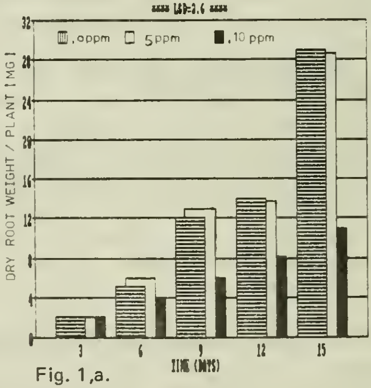

Fig. 1,a.

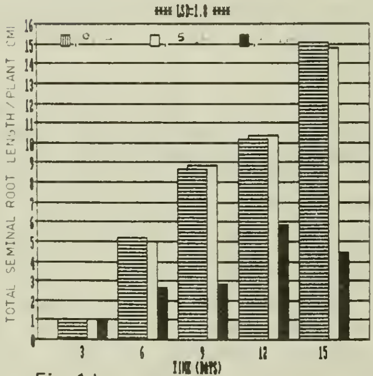

Fig. 1,b.

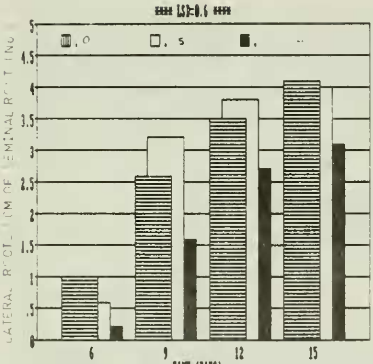

Fig. 1,c.

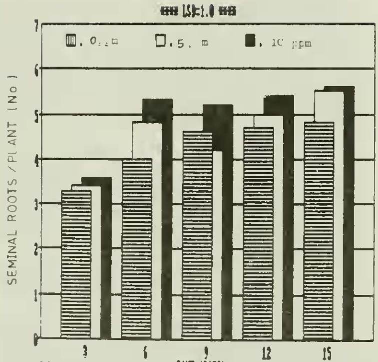

Fig. 1,d.

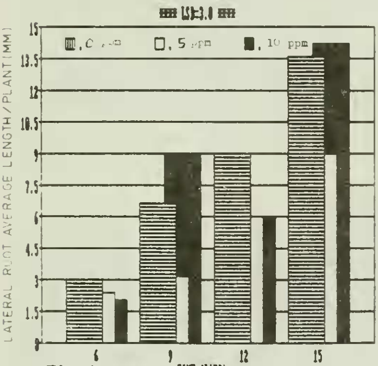

Fig. 1,e.

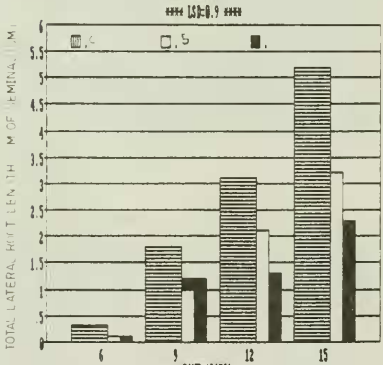

Fig.1,f.

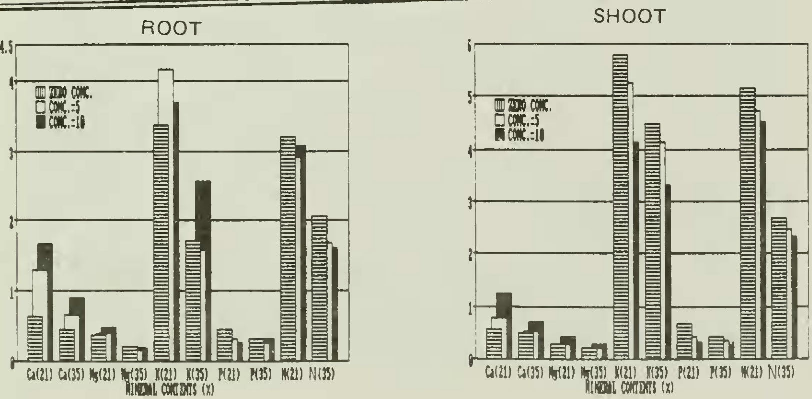

Fig 2 Effect of 2 4-D amine on the mineral contents of Zea plant